Section 6
Evaluating Projects, Resource Management Strategies, and IRWM Plan Benefits with Climate Change

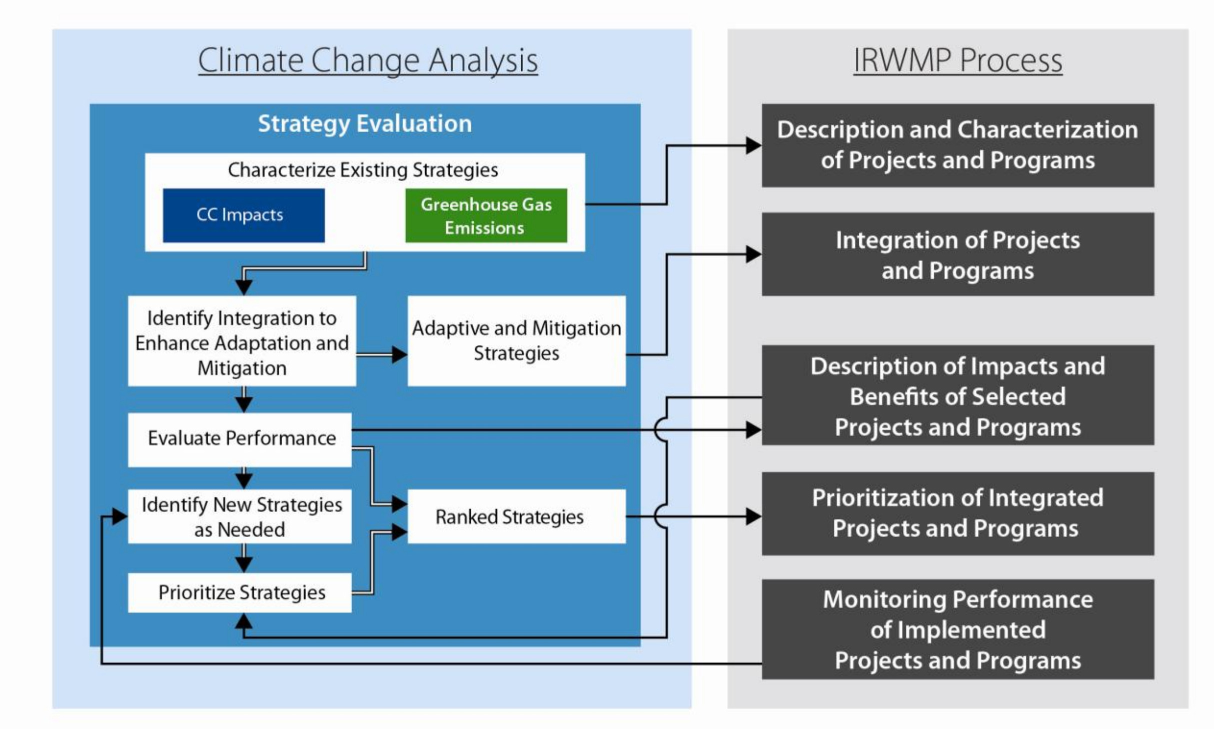

Figure 6-1. Process for Evaluating Strategies as part of an IRWMP.

> ***Project Integration**: Combining or refining individual (and likely local) projects into a single, regional project.*

The analytical methods discussed in Section 5 provide information about projected future conditions in a region that can be used to evaluate IRWM projects, assess strategies, and estimate project and strategy benefits. Many IRWM projects and strategies can provide climate change mitigation, such as projects with lower energy requirements than the status quo. IRWM projects may also enhance climate change adaptation, such as a project that increases water supply flexibility. This section describes the evaluation and comparison of projects and project portfolios for climate change mitigation and adaptation performance. The basic elements associated with evaluating strategies and their resulting projects and programs in the presence of climate change are depicted in Figure 6-1.

In addition to the evaluation of individual projects, this section describes how a climate change evaluation should also address projects collectively (e.g., as a "portfolio" of projects). Project portfolio evaluation is necessary to describe the potential impacts and benefits of an IRWMP. Project portfolio evaluation often requires a separate analysis for two main reasons:

1) The planner may integrate some of the selected projects to achieve synergies and increase cost-effectiveness. Integration can alter individual project characterizations so that portfolio performance is not simply a combination of individual project performances; and

2) The portfolio of projects included in the IRWMP may have benefits that are not equal to the sum of benefits of the individual projects in the plan.

Figure 6-2 presents a potential/typical path for the projects in an IRWMP and where the climate change evaluation takes place. The steps use terminology specific to IRWMPs but common to most regional and watershed-based planning efforts.

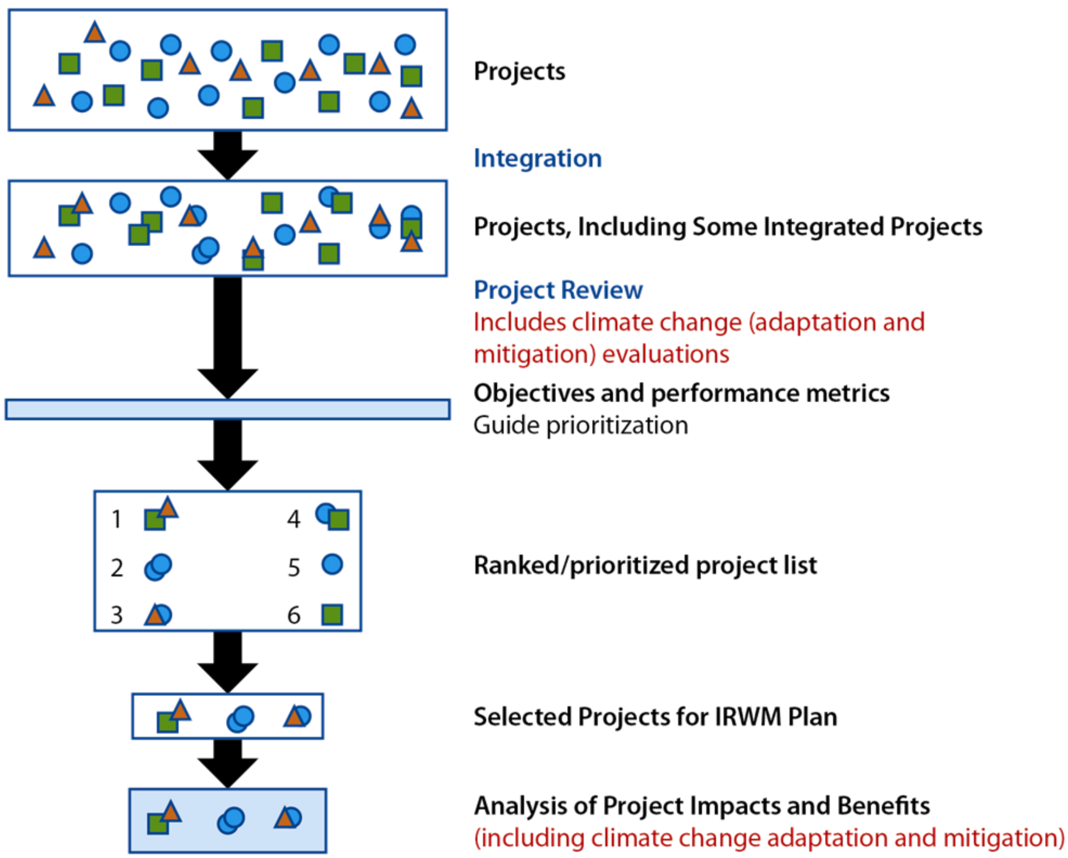

Figure 6-2. Typical Process Leading from Projects to IRWMP Plan.

This section focuses on the importance of incorporating climate change into project performance metrics which includes:

- Quantifying a “baseline” for climate change impact analysis,
- Applying performance metrics that incorporate climate change mitigation and adaptation goals to evaluate projects, integrated projects, and project portfolios,
- Considering Resource Management Strategies in identifying and evaluating projects, and
- Options for weighting and combining performance metrics related to climate change in the evaluation process.

6.1 Climate Vulnerabilities, Objectives, and Performance Metrics

6.1.1 Transition from Vulnerabilities to Performance Metrics

> *A single performance metric for climate change adaptation is not appropriate or adequate.*

The objectives in an IRWMP dictate the analysis needed to characterize projects in the IRWM planning process. A project or program in any regional plan can be characterized in terms of how much it costs, how much water it supplies, how much water it treats, how it may impact a Disadvantaged Community (DAC), or how it enhances habitat. If a plan does not include objectives related to, for example, managing salinity, the planner does not need to evaluate the salinity management benefits of a given project. The objectives and resulting performance metrics dictate the analysis required to evaluate all projects. Climate change adaptation and mitigation goals must be incorporated into the objectives and performance metrics in order to have an influence on a plan’s outcome. Figure 6-3 illustrates potential progression from vulnerabilities identified in Section 4 of this handbook, to performance metrics measured in Section 5 of the handbook, to evaluating projects based on their performance in Section 6 of the handbook.

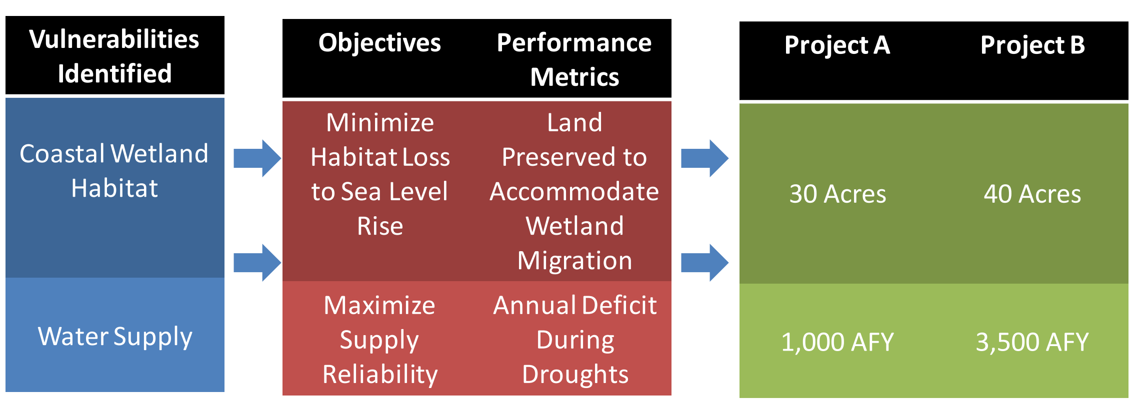

Figure 6-3: Example of Project Contributions to Climate Change Adaptation.

6.1.2 Incorporating Climate Change Objectives with Other Planning Objectives

California's IRWMP standards describe relevant attributes for plan objectives and introduce the concept of a hierarchy of objectives. Table 6-1 illustrates an example of the hierarchy of objectives, sub-objectives, and performance metrics. It also demonstrates how climate change adaptation may be included with other objectives and performance metrics; some of the items in the table are not directly (or even indirectly) related to climate change.

Table 6-1. Example of One Objective, One Sub-Objective with Two Performance Measures (Qualitative and Quantitative)

Objective	Sub-Objective	Performance Metrics
Develop A Reliable Water Supply	Increase water supplied by sources that are not vulnerable to climate change.	Number of sources not vulnerable
		Amount of annual supply with reduced vulnerability
	Develop water supplies that are resistant to earthquakes	Increase in seismically resistant water supplies.

If climate change is incorporated into objectives and performance metrics, the contributions of a project to adapt to and/or mitigate climate change are considered in project development and evaluation, along with other planning objectives. While climate change mitigation is limited to GHG emissions reduction (from a baseline) and GHG sequestration opportunities, adaptation benefits can be found in many watershed and regional functions. Because of this, a single performance metric for climate change adaptation is not appropriate or adequate. Instead, the extent to which a project, a strategy, and the IRWMP as a whole, helps the region adapt to climate change is better described by a series of performance metrics related to more general objectives (as shown in Table 6-1).

When evaluating a project in any planning process (with or without climate change), the combined numerical or qualitative values for performance measures, should reflect the benefits of that project. If climate change is added to the planning process, the climate change adaptation benefits of projects should also be measurable by performance measures. Figure 6-3 illustrates this concept. In the figure, both projects contribute to climate change adaptation. Project B preserves more habitat area than Project A, but Project A is better than Project B in maximizing drought reliability. The planner may chose to create a composite index of climate change adaptation performance using the performance metrics values for each project, as well as information on the weight or priority of the planning objectives. Section 6.6 presents an example of a method to generate a composite index using objective weights. This type of composite evaluation and weighting helps planners evaluate and incorporate tradeoffs involved with various project alternatives.

6.2 Evaluating Project Performance Using Climate Change-Related Performance Metrics

Performance metric evaluation in an IRWMP occurs at three stages: the baseline level, the project level (individual or integrated), and at the IRWMP level for a portfolio of projects. Evaluation at each of these stages is summarized in this section. Climate change considerations are incorporated into this evaluation process in three ways:

1. Any performance metric that may be *influenced by* climate change impacts needs to be quantified in a manner that accounts for this possible influence, as described in Section 5. An example would be the annual yield of a storage project, which is an important metric to characterize such a project, but can be impacted by climate change. Methods discussed in Section 5 can be used to incorporate climate change into evaluating these performance metrics.

2. Some performance metrics may *explicitly address* climate change adaptation. These performance metrics must be quantified and added to the mix of performance metrics that contribute to overall project portfolio ranking and weighting. Examples of performance metrics that explicitly address climate change are included in Figure 6-3. Methods discussed in Section 5 can be used to evaluate these performance metrics.

3. At least one performance metric should *explicitly address* climate change mitigation. These performance metrics must be quantified and added to the mix of performance metrics that contribute to overall project portfolio ranking and weighting. An example of a performance metric explicitly addressing mitigation is emissions of CO_2 equivalent in metric tons per year. Methods discussed in Section 3 can be used to evaluate these performance metrics.

The analyses discussed in Section 5 can also be used to quantify climate change impacts for a "baseline future", which is the existing set of projects and programs in the region. Climate change impacts on the baseline future system contribute to the regional description in an IRWMP, and should influence regional objectives. Baseline performance metrics also provide a basis of comparison for potential projects, project portfolios, and programs.

6.2.1 Baseline (Climate Change Conditions and No New Projects)

The "baseline" conditions are the existing set of environmental conditions and the existing set of regional or local projects and programs. For planning purposes, projecting baseline conditions into the future provides a "no action" alternative analysis. This future baseline identifies how the current set of projects, programs, and infrastructure would perform over the planning period; which is 20 years for IRWMPs (DWR 2010a). Thus, this includes analysis of how changes in population, demographics, land use, economic conditions, and climate are likely to affect conditions in the region. The baseline conditions will help identify both problems that already challenge the region, and problems that will likely challenge the region in the future. Therefore, this analysis helps inform the development of additional objectives aimed at meeting the challenges. The baseline performance also serves as a benchmark from which to compare impacts and benefits of the final plan.

When the baseline conditions are analyzed, all relevant aspects of the regional environment should be incorporated into the analysis. For example, this might include:

- Existing regional characteristics, such as water supplies and demands,
- Ongoing projects and existing institutional programs, such as river or wetland restoration efforts,
- Existing operational policies, such as dam release rules, and
- Existing population, land use, and cropping patterns.

Comparing results from the analyses discussed in Section 5, conducted with and without accounting for climate change, allows planners to quantify climate change impacts. Evaluating the performance of the baseline, however, should *not* include analysis results without climate change considerations. The distinction between quantifying climate change impacts and evaluating baseline performance is depicted in Figure 6-4.

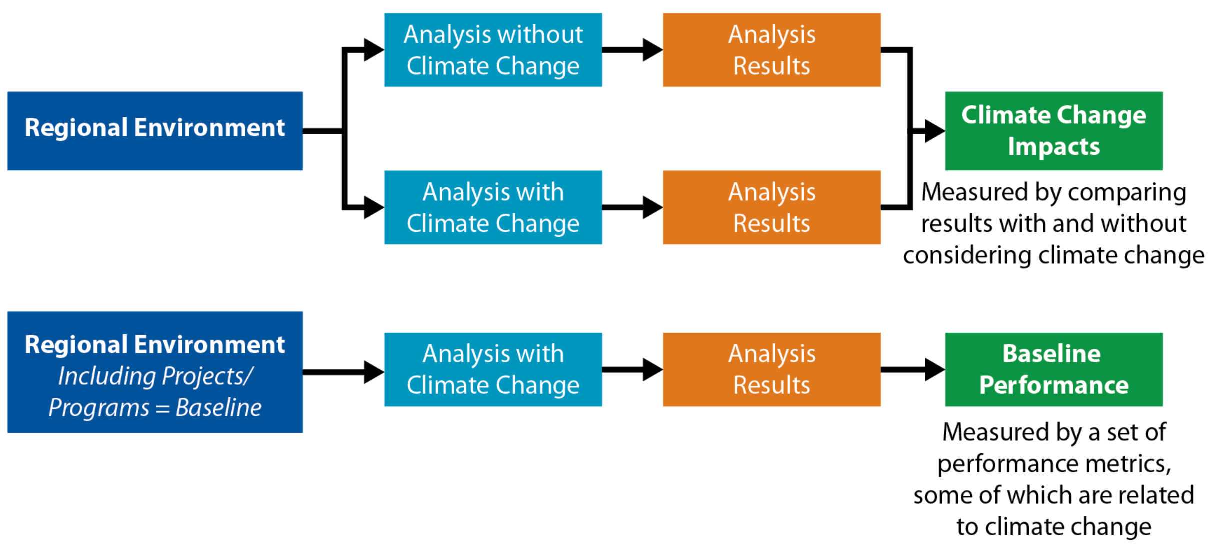

Figure 6-4: Baseline Conditions Performance Metric Evaluation.

Baseline analysis results are translated into performance metrics for comparison with the portfolio of projects and programs included in the IRWMP. Planners can describe the benefits of the plan by comparing the baseline with the portfolio of projects and programs.

6.2.2 Evaluating Individual Projects

Climate change will not impact every project. Planners must evaluate each project to determine if its expected performance might be impacted by climate change. The project then needs to be evaluated using the same assumptions about future climate change (i.e., planning scenarios) that were used to evaluate the baseline future conditions.

In many cases, project performance can be measured by adjusting the baseline analysis to represent inclusion of the project. For example, the change in water supply that would result from a project to raise a reservoir's capacity may require adjustment of a regional water system operational model (such as WEAP or an equivalent – see Section 5 and Appendix D.2). The performance metrics resulting from this new analysis would reflect the adaptation inherent in the project. The process of re-visiting the baseline and adjusting to account for a potential project is depicted in Figure 6-5.

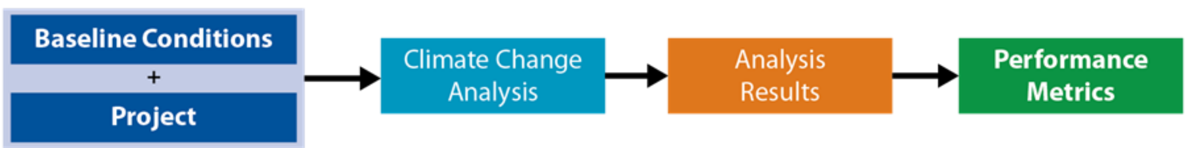

Figure 6-5: Project Performance Metric Evaluation.

6.2.2.1 Project Integration

Project integration can serve as a way to maximize project performance and synergies among projects and minimize conflicts and tradeoffs . Because climate change impacts on various water resources are interrelated, compound effects from integrating projects has the potential to greatly increase adaptation. For example, if habitat preservation projects are integrated with floodplain management projects, both projects are likely to see increased climate adaptation, as many floodplain management strategies involve habitat conservation. Examples of such synergies are discussed throughout this section of the handbook.

6.2.3 Evaluating Project Portfolios

> ***Project Portfolio**: a collection of projects selected in an IRWMP.*

As discussed above, integrated and grouped projects and programs may not have the same benefits and performance as the sum of their individual projects and programs. Portfolios of projects and programs (the list of projects included in the IRWMP) are evaluated against planning performance metrics in the IRWMP process. Portfolio performance evaluation is similar to individual project evaluation. In portfolio evaluation, the baseline conditions are adjusted to reflect all selected projects and programs after integration. The process of adjusting baseline analyses to reflect project portfolios is depicted in Figure 6-6.

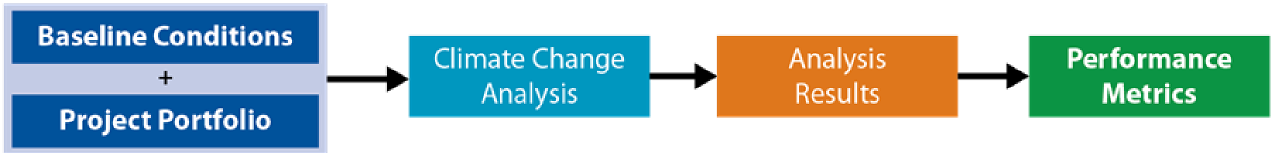

Figure 6-6: Project Portfolio Performance Metric Evaluation.

6.3 Resource Management Strategies

As existing and proposed projects are evaluated, gaps in performance objectives may indicate the need for additional projects. The IRWMP guidelines require consideration of the CWP 2009 Update's Resource Management Strategies (RMSs) in identifying projects for IRWMPs. The CWP dedicates Volume II to discussing these RMSs. Because the CWP discussion is comprehensive and includes strategies that apply to most climate change adaptation and/or mitigation projects, this handbook uses the CWP RMSs as a basis for RMS discussion. The CWP also includes many region-specific RMSs, which regions should consider in project development. In addition, many regions have their own priorities and strategies. Many other sources provide detailed information on adaptation strategies, and are included in Appendix A of this handbook. The general CWP RMSs include:

1. Reduce Water Demand:
    - Agricultural Water Use Efficiency, and
    - Urban Water Use Efficiency.
2. Improve Operational Efficiency and Transfers:
    - Conveyance – Delta,
    - Conveyance – Regional/local,
    - System Reoperation, and
    - Water Transfers.
3. Increase Water Supply:
    - Conjunctive Management and Groundwater Storage.
    - Desalination,
    - Precipitation Enhancement,
    - Recycled Municipal Water,
    - Surface Storage – CALFED, and
    - Surface Storage – Regional/local.
4. Improve Water Quality:
    - Drinking Water Treatment and Distribution,
    - Groundwater Remediation/Aquifer Remediation,
    - Matching Quality to Use,
    - Pollution Prevention, and
    - Salt and Salinity Management.

5. Urban Runoff Management (including Low Impact Development[1])
6. Practice Resource Stewardship:
    - Agricultural Lands Stewardship,
    - Economic Incentives (Loans, Grants, and Water Pricing),
    - Ecosystem Restoration,
    - Forest Management,
    - Land Use Planning and Management,
    - Recharge Area Protection,
    - Water-dependent Recreation, and
    - Watershed Management.
7. Improve Flood Management:
    - Flood Risk Management.
8. Other Strategies:
    - Crop Idling for Water Transfers,
    - Dewvaporation or Atmospheric Pressure Desalination,
    - Fog Collection,
    - Irrigated Land Retirement,
    - Rainfed Agriculture, and
    - Waterbag Transport/Storage Technology.

The California Climate Adaptation Strategy provides another set of adaptation strategies that are targeted at specific sectors (e.g., water, agriculture, health). Adaptation strategies from the California Climate Adaptation Strategy that are specifically applicable to IRWMPs are listed below (CNRA 2009):

- Aggressively increase water use efficiency, targeting:
    - Water efficiency,
    - Energy efficiency, and
    - Water conservation.
- Practice and promote integrated flood management by improving:
    - Flood management,
    - System reoperation, and
    - Land use policies.

[1] Low Impact Development is an increasingly important RMS that enhances pollution prevention, aquifer recharge, and overall watershed health. For more information, visit the Low Impact Development Center: http://www.lowimpactdevelopment.org/

- Enhance and sustain ecosystems, targeting:
    - Species migration and movement corridors,
    - Floodplain corridors,
    - Anadromous fish,
    - Tidal wetlands as buffers,
    - Reversal of Delta island subsidence, and
    - Upper watershed services.
- Expand water storage and conjunctive management of surface and groundwater resources by:
    - Expanding water storage,
    - Conducting surface storage feasibility studies,
    - Developing conjunctive use management plans and groundwater management plans, and
    - Implementing local ordinances.
- Fix Delta water supply:
    - Participate in Delta adaptation planning.
- Preserve, upgrade, and increase monitoring, data analysis, and management, targeting:
    - Climate monitoring,
    - Atmospheric observations,
    - Water use feasibility studies, and
    - Water use accountability.
- Plan for and adapt to sea level rise.

The set of RMSs appropriate for a region depends on regional needs, vulnerabilities, and priorities. If a region's list of potential projects and programs does not meet the region's objectives regarding climate change adaptation, additional projects may be added that incorporate additional climate change adaptation strategies. In addition, launching or augmenting a comprehensive data collection and monitoring program may be needed, especially in cases where data availability limits comprehensive analysis. Section 6.3.1 discusses ways in which various RMSs can be applied to climate change adaptation and/or mitigation, and some performance metrics that could quantify any adaptation/mitigation.

__Resilience__: The ability of a system to absorb some amount of change, including shocks from extreme events, bounce back and recover from them, and, if necessary, transform itself in order to continue to be able to function and provide essential services and amenities that it has evolved or been designed to provide.

--- IPCC 2001

Not all of the CWP RMSs directly apply to climate change adaptation or mitigation efforts. Instead, many are directed at overall system resiliency, which also improves resilience to climate change impacts.

6.3.1 Adaptation Strategies

This section discusses ways in which each of the CWP RMSs can be used to adapt to climate change. It also discusses some ways that the RMS performance can be impacted by climate change. All discussions in this section are necessarily generic given that the applicability of any RMS to climate change adaptation is specific to the project, the specific climate change impact, and the region.

Table 6-2 summarizes the CWP strategies and their potential ability to aid in climate change adaptation. Many strategies have multiple potential benefits, indicating potential synergies among projects that result from these strategies.

6.3.1.1 Reduce Water Demand

The Reduce Water Demand strategy includes water use efficiency measures for urban and agricultural water use. California has made progress in encouraging water conservation and water use efficiency. The state's 20x2020 Water Conservation Plan (20x2020 Plan) (http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/index.shtml) includes measures that can, and should, be taken to conserve urban water use. Many of the strategies discussed in the 20x2020 Plan could potentially be expanded to further increase conservation efforts. In water demand/supply projections, however, it is important that regions not "double count" water conservation measures – if demand projections already account for 20x2020 Plan conservation targets, only strategies that expand on the 20x2020 Plan conservation measures should be considered additional demand reductions.

Municipal and irrigation demands are both potential sources of water conservation. According to the 20x2020 Plan, landscape water use has the greatest potential for reduction of any urban water use sector.

Table 6-2. Applicability of CWP Resource Management Strategies to Climate Change Adaptation

Resource Management Strategies	Climate Change Adaptation							
	Habitat Protection	Flood Control	Water Supply Reliability	Additional Water Supply	Water Demand Reduction	Sea Level Rise	Water Quality Protection	Hydropower
Reduce Water Demand								
Agricultural Use Efficiency			✓		✓		✓	
Urban Water Use Efficiency			✓		✓		✓	
Improve Operational Efficiency and Transfers								
Conveyance – Delta	✓	✓	✓	✓		✓	✓	
Conveyance – Regional/local	✓	✓	✓	✓			✓	
System Reoperation		✓	✓	✓				✓
Water Transfers			✓	✓				
Increase Water Supply								
Conjunctive Management and Groundwater Storage		✓	✓	✓			✓	
Desalination			✓	✓				
Precipitation Enhancement				✓				✓
Recycled Municipal Water			✓	✓				
Surface Storage – CALFED	✓	✓	✓	✓			✓	✓
Surface Storage – Regional/local	✓	✓	✓	✓			✓	✓
Improve Water Quality								
Drinking Water Treatment and Distribution			✓	✓			✓	
Groundwater Remediation/Aquifer Remediation			✓	✓			✓	
Matching Quality to Use			✓	✓			✓	
Pollution Prevention	✓		✓				✓	
Salt and Salinity Management	✓		✓	✓			✓	
Urban Runoff Management	✓	✓					✓	
Practice Resource Stewardship								
Agricultural Lands Stewardship	✓	✓			✓		✓	
Economic Incentives (Loans, Grants and Water Pricing)	✓	✓	✓	✓	✓	✓	✓	✓
Ecosystem Restoration	✓	✓	✓			✓	✓	
Forest Management	✓	✓	✓				✓	
Land Use Planning and Management	✓	✓				✓	✓	
Recharge Area Protection		✓	✓	✓			✓	
Water-dependent Recreation	✓	✓	✓				✓	
Watershed Management	✓	✓	✓	✓		✓	✓	✓
Improve Flood Management								
Flood Risk Management	✓	✓				✓	✓	✓
Other Strategies								
Crop Idling for Water Transfers			✓	✓	✓			
Dewvaporation or Atmospheric Pressure Desalination				✓				
Fog Collection				✓				
Irrigated Land Retirement			✓		✓			
Rainfed Agriculture					✓			
Waterbag Transport/Storage Technology	✓		✓	✓		✓	✓	

The Agricultural Water Management Council (www.agwatercouncil.org) promotes several efficient water management practices (EWMPs). EWMPs include infrastructure and operational improvements, such as canal lining and pump operation optimization. EWMPS also include district level management activities, such as facilitating recycled urban water use and other supporting efforts.

Performance metrics that could quantify water use efficiency project adaptation include:

- Average (annual) water demand reduction, and
- Peak (seasonal, monthly) water demand reduction.

6.3.1.2 Improve Operational Efficiency and Transfers

The Improve Operational Efficiency and Transfers strategy includes optimizing system operations to maximize efficiency. It also includes maintaining and improving existing infrastructure for regional and local conveyance, including facilities in the Delta and throughout the SWP and CVP.

Through system reoperation, regions may be able to adapt to climate change impacts on hydropower production. Regions may also be able to adapt to lower or less reliable water supplies and/or increased water demands by maintaining conveyance infrastructure. Well maintained conveyance infrastructure can also improve regional adaptation to climate change impacts on flooding, habitats, and water quality. Water transfers can help adapt to climate change by providing a region with additional water supply.

Performance metrics that could quantify operational efficiency or transfer project adaptation include:

- Additional supply, and
- Supply reliability.

6.3.1.3 Increase Water Supply

Potential additional supply sources include increased storage in ground and surface facilities, precipitation enhancement, recycled water use, and desalination. The California Recycled Water Policy (http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf) goals include substituting as much recycled water for potable water as possible by 2030. Increased storage and conjunctive use may also increase resilience to shifting runoff patterns, providing more storage for early runoff. This strategy is an adaptation measure for increased demands and/or decreased supplies or supply reliability.

Performance metrics that could quantify water supply project adaptation include:

- Additional supply,
- Potable demand offset, and
- Supply reliability.

6.3.1.4 Improve Water Quality

Improving water quality includes improving drinking water treatment and distribution, groundwater remediation, matching water quality to use, pollution prevention, salinity management, and urban runoff management. These strategies may help a region adapt to not only water quality impacts from climate change, but ecosystem impacts from sea level rise, and other climate stressors as well. They may also contribute to providing additional supplies. For example, stormwater capture can provide a seasonal source of irrigation water for urban landscaping.

Performance metrics that could quantify water quality project adaptation include:

- Salt line migration,
- Stream temperature,
- Dissolved oxygen,
- Turbidity, and
- Pollutant concentrations.

6.3.1.5 Practice Resource Stewardship

Resource stewardship includes stewardship of land, wildlife, and water by way of conservation and preservation, ecosystem restoration and forest management, watershed management, flood attenuation, and water-dependent recreation. Restoring and preserving habitat and wetlands has multiple benefits. In addition to promoting biodiversity and habitat enhancement, riparian habitat restoration can be a key aspect of integrated flood management, as the natural storage provided by riparian wetlands can serve as buffers that absorb peak flows and provide slow releases after storm events (DWR 2008). Because the scope of resource stewardship includes all resources, these strategies can help adapt to climate change impacts in various ways, depending on project-specific details.

Because resource stewardship is so broad, performance metrics that could quantify resource stewardship project adaptation are also broad. Some examples include:

- Presence/absence of key indicator species,
- Acres of a certain habitat or floodplain function restored/protected, and
- Volume of natural flood storage provided.

6.3.1.6 Improve Flood Management

Flood management involves emergency planning, general planning activities (e.g., infrastructure improvements), and policy changes (e.g., defining new hazard zones). Flood management strategies can help a region adapt to many other climate change impacts, including ecosystem vulnerabilities and water quality. Performance metrics that could quantify flood management project adaptations include:

- Acres of a certain habitat or floodplain function restored/protected,
- Volume of natural flood storage provided,
- Storm return period used for planning, and
- Expected damage resulting from a certain return period storm.

6.3.1.7 Other Strategies

Other resource management strategies in the CWP include obtaining additional water supplies, such as fog capturing and waterbag transport technology. Additional conservation and demand reduction measures, such as crop idling, irrigated land retirement, and rainfed agriculture are also discussed. Waterbag transport could be used to target water quality and ecosystem protection, for instance to supplement freshwater inflows in estuaries. Fog capture, and other supply/conservation measures, could be used to adapt to climate change-induced demand increases or decreases in supply/supply-reliability.

6.3.2 Strategies for Climate Change Mitigation

Implementation of mitigation strategies can reduce GHG emissions from the baseline, or minimize increases in GHG emissions as much as possible. This can be done by:

- Carbon sequestration through vegetation growth,
- GHG emission reductions, accomplished by:
    - *Energy use efficiency*. Implementing green infrastructure and utilizing Leadership in Energy and Environmental Design (LEED) certified building technologies can save energy by reducing emissions from carbon-based energy sources.
    - *Use of renewable energy sources*. Installing roof-mounted solar panels and optimizing hydropower generation reduces reliance on carbon-based fuels which can reduce emissions.
    - *Energy-efficient water demand reduction*. While some water conservation strategies are energy-intensive, many strategies help reduce energy consumption; lowering water demands also lowers energy requirements associated with water conveyance, treatment, and distribution.

The CWP strategies presented in this section could help increase energy-use efficiency or reduce emissions. Table 6-3 also summarizes strategies assist to mitigation efforts.

Table 6-3. Applicability of CWP Resource Management Strategies to Greenhouse Gas Mitigation

Resource Management Strategies	Greenhouse Gas Mitigation		
	Energy Efficiency	Emissions Reduction	Carbon Sequestration
Reduce Water Demand			
Agricultural Use Efficiency	✓	✓	
Urban Water Use Efficiency	✓	✓	
Improve Operational Efficiency and Transfers			
Conveyance – Delta	✓	✓	
Conveyance – Regional/local	✓	✓	
System Reoperation	✓	✓	
Water Transfers[1]	X		
Increase Water Supply			
Conjunctive Management and Groundwater Storage[1]	X		
Desalination[1]	X	X	
Precipitation Enhancement		✓	
Recycled Municipal Water	✓	✓	
Surface Storage – CALFED		✓	
Surface Storage – Regional/local		✓	
Improve Water Quality			
Drinking Water Treatment and Distribution			
Groundwater Remediation/Aquifer Remediation			
Matching Quality to Use	✓		
Pollution Prevention		✓	
Salt and Salinity Management		✓	
Urban Runoff Management	✓	✓	
Practice Resource Stewardship			
Agricultural Lands Stewardship	✓	✓	✓
Economic Incentives (Loans, Grants and Water Pricing)	✓	✓	✓
Ecosystem Restoration			✓
Forest Management			✓
Land Use Planning and Management	✓	✓	✓
Recharge Area Protection			✓
Water-dependent Recreation		✓	
Watershed Management			✓
Improve Flood Management			
Flood Risk Management			✓
Other Strategies			
Crop Idling for Water Transfers		✓	
Dewvaporation or Atmospheric Pressure Desalination	✓	✓	
Fog Collection			
Irrigated Land Retirement			
Rainfed Agriculture	✓	✓	✓
Waterbag Transport/Storage Technology	X	X	

Key:
✓ Indicates that in general this will provide a beneficial effect
X Indicates that in general this will provide an adverse effect
[1] The net effect may be positive or negative, depending on the source of water that is offset by implementing the strategy

The California Climate Change Scoping Plan (CARB 2008) has several recommendations for increasing energy efficiency, reducing GHG emissions, and increasing reliance on renewable energy. Among these recommendations are the use of energy efficient and alternate fuel vehicles, reliance on solar panels and other renewable energy sources, and energy-efficient buildings. These recommendations can be worked into several of the CWP strategy elements, especially the strategies that include higher energy consumptions.

Performance metrics that quantify mitigation-related characteristics for the RMSs include:

- Project-related GHG emissions, relative to baseline (no project) emissions if appropriate (Section 3 discusses GHG emissions inventories),
- Carbon sequestered per year, and
- Energy savings (including savings from water use conservation/efficiency).

6.3.2.1 Reduce Water Demand

The Reduce Water Demand strategy includes water use efficiency measures for urban and agricultural water use. Conservation is an ideal way to reduce emissions by saving water and energy. Municipal and irrigation demands are both potential sources of water conservation.

6.3.2.2 Improve Operational Efficiency and Transfers

The strategy to Improve Operational Efficiency and Transfers includes optimizing water system operations to maximize efficiency. Maintaining and improving existing regional and local conveyance infrastructure is critical for regional and local conveyance, including facilities in the SWP and CVP.

Improving operational efficiency can indirectly reduce emissions by reducing system losses. However, many water transfers are relatively high in energy costs. As for all projects, the potential carbon footprint needs to be compared with other supply alternative projects.

6.3.2.3 Increase Water Supply

Potential additional supply sources include increased storage in ground and surface facilities, precipitation enhancement, recycled water use, and desalination. This strategy is an adaptation measure for increased demands and/or decreased supply or supply reliability.

The carbon footprint associated with increasing water supply depends a great deal on the individual strategies selected. Desalinated water and water imported from distant regions with high pumping requirements have very high carbon footprints. The high energy requirements also translate into a high cost per acre-foot of yield. Pumping requirements associated with groundwater projects may also be high. Other options, such as increasing water storage, may increase GHG emissions (i.e., via additional pumping and emissions) associated with project construction, but may have relatively low operational GHG emissions.

6.3.2.4 Improve Water Quality

The strategy to Improve Water Quality includes improving drinking water treatment and distribution, groundwater remediation, matching water quality to use, pollution prevention, salinity management, and urban runoff management. GHG emissions and energy requirements associated with the project depend on project-specific details, but matching water quality to use is generally lower in energy costs than the potable water provision that it replaces. Pollution prevention also saves money and effort that would be dedicated to treatment in the longer term.

6.3.2.5 Practice Resource Stewardship

The strategy of Resource Stewardship includes practices that improve the stewardship of land, wildlife, and water by way of conservation and preservation, ecosystem restoration and forestand watershed management, and water-dependent recreation. These strategies can help reduce carbon emissions by reducing the treatment requirements. Stewardship practices can decrease the total emissions by contributing to carbon sequestration in cases where vegetation growth is enhanced by projects.

6.3.2.6 Improve Flood Management

Flood management involves emergency planning, general planning activities (e.g., infrastructure improvements), and policy changes (e.g., defining new hazard zones). Flood management touches on many other categories, such as ecosystem protection and water quality. Where flood management projects encourage vegetation growth, carbon sequestration can potentially reduce net carbon emissions.

Flood management requirements on dam operation can compete with hydroelectric energy production, which may increase overall project, and regional, GHG emissions.

6.3.2.7 Other Strategies

Other climate change mitigation strategies in the CWP include obtaining additional water supplies, such as fog capture and waterbag transport technology. These strategies are varied and often involve emerging and innovative technologies.

Rainfed agriculture, irrigated land retirement, and crop idling may all reduce GHG emissions by conservation. Dewvaporization is less energy intensive than traditional desalination, but the method is still under development. Other methods, such as fog capture and waterbag technologies, may require more intensive energy inputs for transportation or conveyance.

6.4 Climate Change Impacts on RMSs

Some projects, including projects that can be used as part of strategies to adapt to climate change, can provide different results in the presence of climate change. These climate change impacts on adaptation/mitigation projects can be thought of as "residual" climate change impacts, or impacts that may occur even with adaptation measures present. Figure 6-7 depicts the relationship by which climate change impacts can be reduced by implementing some projects while the projects' performance can be impacted, in turn, by climate change.

To illustrate implementation of the tools discussed in Section 5 and other portions of Section 6 for project evaluation, this section provides example project evaluation methodologies that may apply to the CWP RMSs. The following subsections discuss a sample project for each overall RMS from the CWP (except "Other Strategies"). Items discussed for each project include:

- How the project may help the region *adapt* to climate change,
- Potential performance metrics and ways that they could be *influenced by* climate change, and
- Methods to account for the impacts in performance metric calculation.

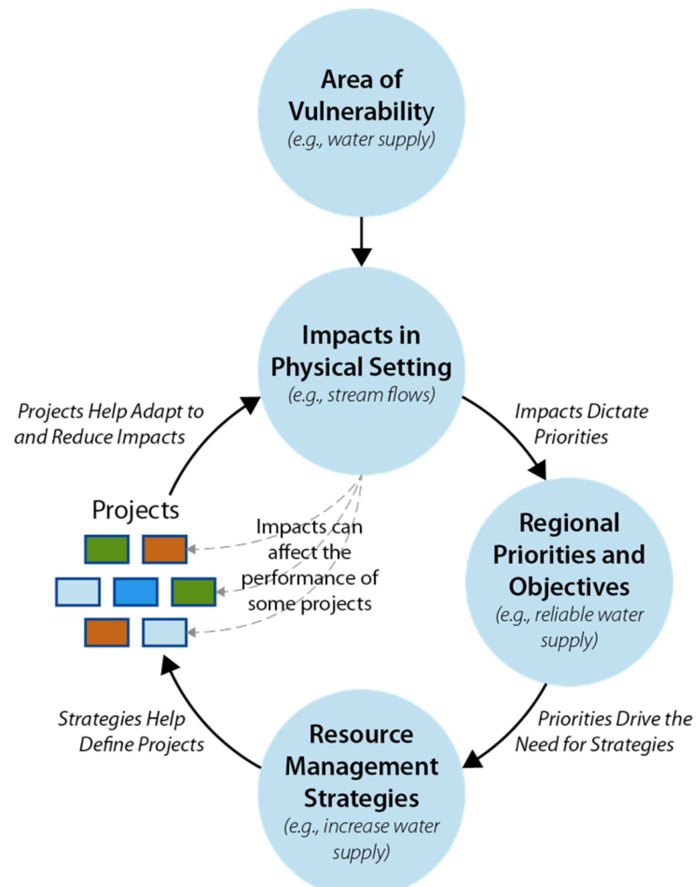

Figure 6-7: Climate Change Impacts on Physical Setting and Projects.

Table 6-4 summarizes climate change impact measurement methods for the CWP RMS. Project evaluations resulting from the analyses discussed in this section contribute to project ranking for the development of IRWMP implementation strategies.

Table 6-4. Examples of the Types of Technical Analysis to Assess Potential Impacts of Climate Change on Performance of RMSs

Resource Management Strategies	Type of Technical Analysis to Assess Impact	Potential Climate Change Impact
Reduce Water Demand		
Agricultural Use Efficiency	Evaluation of ET impacts and demand elasticity to weather	Water Demand
Urban Water Use Efficiency	Evaluation of demand elasticity to weather	Water Demand
Improve Operational Efficiency and Transfers		
Conveyance – Delta	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Storm intensity and/or snow-line migration - streamflows	Flooding
	Inundation analysis	Sea Level Rise
Conveyance – Regional/local	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Storm intensity and/or snow-line migration - streamflows	Flooding
System Reoperation	Watershed, streamflows and water system analysis	Water Supply
	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
Water Transfers	Watershed Analysis - streamflow projections and water availability	Water Supply
Increase Water Supply		
Conjunctive Management and Groundwater Storage[1]	NA	NA
Desalination	Salt intrusion analysis (if open coastal intake or coastal discharge)	Water Quality
Precipitation Enhancement	Analysis of future climate (temperature, cloud cover, e.g.) on project functionality	Project-specific
Recycled Municipal Water	Agricultural (ET) and/or urban RW demand elasticity to weather	Water Demand Analysis
Surface Storage – CALFED	Temperature, dissolved oxygen, pollutant loading analysis	Water Quality
	Watershed Analysis - Streamflow projections	Water Supply
Surface Storage – Regional/local	Temperature, dissolved oxygen, pollutant loading analysis	Water Quality
	Watershed Analysis - Streamflow projections	Water Supply
Improve Water Quality		
Drinking Water Treatment and Distribution	Raw water stream/reservoir water quality analysis	Water Quality
Groundwater Remediation/Aquifer Remediation[1]	NA	NA

Table 6-4. Examples of the Types of Technical Analysis to Assess Potential Impacts of Climate Change on Performance of RMSs

Resource Management Strategies	Type of Technical Analysis to Assess Impact	Potential Climate Change Impact
Matching Quality to Use	Agricultural (ET) and/or urban irrigation and other urban demand elasticity to weather	Water Demand
	For untreated water use: temperature, dissolved oxygen, pollutant loading analysis	Water Quality
	For untreated water use: streamflow analysis	Water Supply
Pollution Prevention	Streamflow analysis	Water Quality
	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	
Salt and Salinity Management	Watershed Analysis - Streamflow projections	Water Quality
	Salinity intrusion analysis	
Urban Runoff Management	Temperature, dissolved oxygen, pollutant loading analysis	Water Quality
	Urban Watershed Analysis – storm drain Streamflow analysis	Flooding
Practice Resource Stewardship		
Agricultural Lands Stewardship	Storm Intensity Analysis	Flooding
	Temperature, dissolved oxygen, pollutant loading analysis	Water Quality
Economic Incentives (Loans, Grants and Water Pricing)[1]	NA	NA
Ecosystem Restoration	Storm intensity and/or snow-line migration - streamflows and wetland inflows	Flooding
	Sea Level Rise-induced marsh migration	Sea Level Rise
	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
Forest Management	Temperature, dissolved oxygen, pollutant loading analysis	Water Quality
	Watershed Analysis - streamflow projections and water availability	Water Supply
Land Use Planning and Management	Storm intensity and/or snow-line migration - streamflows	Flooding
	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Evaluation of ET impacts and demand elasticity to weather	Water Demand
Recharge Area Protection	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Watershed Analysis - streamflow projections and water availability	Streamflow
	Storm intensity and/or snow-line migration - streamflows	Flooding

Table 6-4. Examples of the Types of Technical Analysis to Assess Potential Impacts of Climate Change on Performance of RMSs

Resource Management Strategies	Type of Technical Analysis to Assess Impact	Potential Climate Change Impact
Water-dependent Recreation	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Watershed and streamflow analysis, water system analysis (for reservoir level estimates, e.g.)	Streamflow
	Storm intensity and/or snow-line migration - streamflows	Flooding
	Coastal inundation and erosion analysis	Sea Level Rise
Watershed Management	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Watershed Analysis - streamflow projections and water availability	Streamflow
	Storm intensity and/or snow-line migration - streamflows	Flooding
	Coastal inundation and erosion analysis	Sea Level Rise
Improve Flood Management		
Flood Risk Management	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Storm intensity and/or snow-line migration - streamflows	Flooding
Other Strategies		
Crop Idling for Water Transfers	Evaluation of ET impacts and demand elasticity to weather	Water Demand
Dewvaporation or Atmospheric Pressure Desalination	Analysis of future climate (temperature, cloud cover, e.g.) on project functionality	project-specific
Fog Collection	Analysis of future climate (temperature, cloud cover, e.g.) on project functionality	project-specific
Irrigated Land Retirement	Evaluation of ET impacts and demand elasticity to weather	Water Demand
Rainfed Agriculture	Evaluation of ET impacts and demand elasticity to weather	Water Demand
Waterbag Transport/Storage Technology	Salinity intrusion and/or temperature, dissolved oxygen, pollutant transport analysis	Water Quality
	Watershed Analysis - streamflow projections and water availability	Water Supply

[1] Some RMSs are related to resources that are not associated with an accepted analysis method that addressed climate change. For these RMSs, the "Type of Analysis" and "Potential Climate Change Impact" are designated "NA", or "Not Available".

6.4.1 Reduce Water Demand

One of the Agricultural Water Management Council EWMPs is to convert irrigation canals and ditches to piping. This water conservation method prevents evaporative losses, especially as temperatures rise. Thus, this could help a region adapt to climate change by expanding water supplies and making existing water supplies less vulnerable to evaporative losses.

A potential performance metric that specifically applies to this project could be water demand reduction. This metric could be influenced by climate change because evaporation from irrigation ditches and canals is a function of temperature and other climate variables that are altered by climate change. Considering climate change would influence the total demand reduction accomplished by the project.

Methods for measuring the impact of climate change on evaporative water losses could include developing a regression model between historical temperature and historical evaporation rates, then applying this relationship to projected temperatures. Alternatively, projected evaporative losses could be estimated from the suite of climate variables projected by GCM data. Regression versus process-based climate change analysis is discussed in Section 5.2.2.

6.4.2 Improve Operational Efficiency and Transfers

Water transfers can serve as an alternate water supply for some regions. This can improve supply reliability when other supplies are projected to have lowered reliability due to climate change impacts.

A performance metric that potentially applies to this project is the additional water supply provided. Depending on the source of the transferred water, this metric could be influenced by climate change.

Methods for incorporating climate change into performance metric calculations for this example, include developing or adjusting a watershed modeling analysis, such as those described in Section 5.3.2.

6.4.3 Increase Water Supply

Developing a project to provide additional local surface storage is a possible adaptation strategy for climate change impacts on water supply or water supply reliability. Storage provides a way of adjusting a water system to altered peak streamflow timing resulting from earlier snowpack melting. Additional storage capacity can help regions to adapt to larger precipitation variability.

The ability for additional storage to provide additional supply reliability depends on both evaporative losses exiting the storage facility and on streamflows (or other source flows) entering the facility. Methods for evaluating potential evaporative losses include those discussed in section 6.3.1. However, if the storage facility is included in a larger watershed model (such as those discussed in Section 5.3.2) that has been adjusted for climate change, evaporative losses may be adjusted within the model's calculations. Methods for evaluating potential flows into the storage facility can be calculated using watershed models, such as those discussed in Section 5.3.2.

6.4.4 Improve Water Quality

Stormwater capture and reuse projects can reduce the burden on treatment plants and potable water supplies, helping a region adjust to climate change impacts on water quality.

A performance metric that applies to stormwater capture could be the reduction in pollutant loading to receiving waters. Climate change could influence this metric for a stormwater capture project, due to an altered hydrograph or precipitation pattern. Measuring demand offset for this project would, therefore need to incorporate precipitation projections from climate models. Any existing urban runoff water quality models would also need to be adjusted for climate change. Water quality models are discussed in Section 5.3.3.

6.4.5 Practice Resource Stewardship

Projects that include coastal restoration elements can help regions adjust to climate change by creating a water quality and flooding buffer against sea level rise or storm surges. Potential performance metrics for this type of project could be the estimated changes in salinity intrusion into groundwater wells or expected damages from storm surges. Climate change impacts on coastal ecosystems can be assessed in a variety of ways including qualitatively by surveying local experts, as discussed in Section 5.2.3.

6.4.6 Improve Flood Management

Restoring, managing, and protecting wetlands can improve flood control by retaining, and slowly releasing, stormwater. Wetlands can also improve runoff water quality. This can help a region adapt to anticipated increased storm intensity as the climate changes. A potential performance metric for a wetland restoration project could be stormwater retention volume, or measureable water quality improvements of runoff directed to wetlands.

The capacity of a wetland to retain stormwater is a function of ecosystem health. Climate change can influence wetland health by changes in overall stream inflows and precipitation, and also by climate change impacts on water quality parameters (e.g., dissolved oxygen). Streamflows into wetlands can be calculated using watershed models as described in Section 5.3.2.Water quality can be assessed using models such as those described in Section 5.3.3.

6.5 Prioritizing Projects

After the project evaluation process, the evaluation results can be used for prioritization. The IRWMP can include all of the projects evaluated, a prioritized list of projects, or a limited list of projects that are more likely to provide the benefits to the region.

There are a number of methods for prioritization of projects which regions should already be familiar with from past planning process. Each region must decide on a method to short-list or rank projects. In every method, the performance metrics will be useful in providing objective information for a defensible prioritization.

If the planner considers that a relevant criterion for project evaluation is the overall contribution of a project to climate change adaptation, a composite index can be estimated. This section presents a sample method to develop such a composite index. This method, the Multi-Attribute Rating Technique (MART), utilizes the performance values for each performance metric of interest. The weight of the objectives is associated with each performance measure.

6.5.1 Developing a Composite Index

In order to use MART, a numerical value is required for each performance metric. Thus, if some qualitative performance metrics exist, they must be converted into numerical values. For example, if the qualitative scores are “high”, “medium”, and “low”; they can be replaced with a scale of 1, 2, and 3; or -1, 0, and 1. These numeric values can then be used in MART to develop the index.

Similarly, the plan objectives need to be prioritized, and a numerical value needs to be provided to reflect the objective’s relative importance. A number between 0% and 100% is required for MART.

Since different performance metrics have different units, the development of a composite index requires a unitless score that can then be added for all performance metrics. For every performance metric, a normalization scale is required. In the example below, a normalization has been performed with normalized scores between 0 and 1. A linear scale has been used giving the best value (0 acre-feet per year (AFY) in deficit) a score of 1, and the worst value (5,000 AFY deficit) a score of 0.

Normalized scores are multiplied by the weight of the objective associated with the performance metric. The weighted score is all metrics added together. In the example shown in Table 6-5 and Figure 6-8, below (continued from Figure 6-2), the best normalized weighted score is 0.785 for Project A, whereas Project B has a normalized weighted score of 0.51. In this example, Project A would be more effective at achieving the objectives, given its performance, and the weight of the planning objectives.

This composite index is not a requirement for project prioritization, but it can help interpret the technical analysis performed for the projects, and can support the planner in making decisions about which projects would merit inclusion in the IRWMP. In the example, a tradeoff between two objectives is compared by looking at an overall composite project score.

Table 6-5: Example of Performance Metric Scoring Using a Composite Index.

		Performance Metrics		
		Annual Deficit During Droughts	Habitat Area Preserved	Total Score
Parameters	Objective Weights	0.7	0.3	
	Best Possible Performance by a Project	0 AF	40 acres	
	Worst Possible by a Project	5,000 AF	0 acres	
Performance	Project A	1,000 AFY	30 acres	
	Project B	3,500 AFY	40 acres	
Normalized Performance for each Metric	Project A	0.8	0.75	
	Project B	0.3	1	
Weighted Performance for each Metric	Project A	0.56	0.225	0.785
	Project B	0.21	0.3	0.51

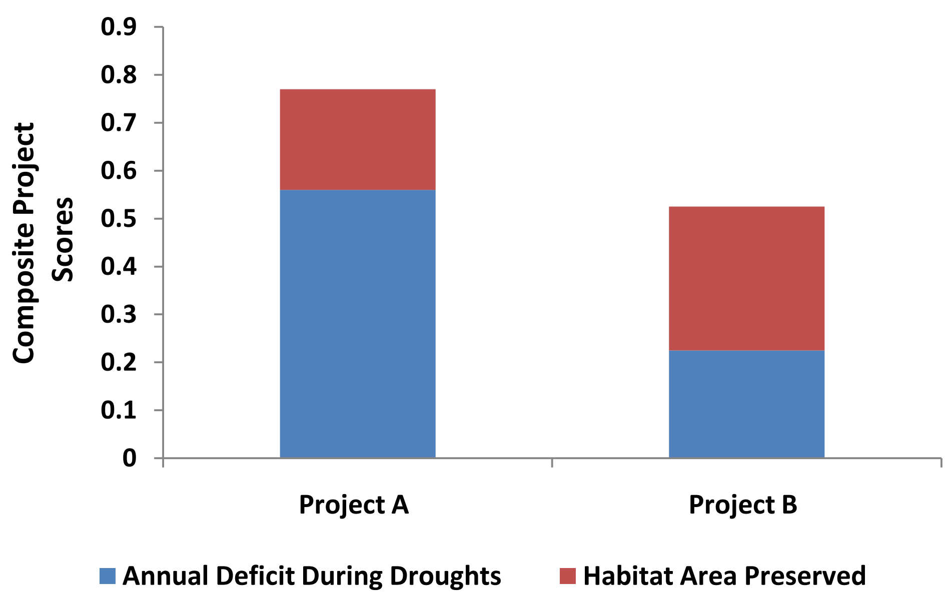

Figure 6-8: Example Composite Climate Change Adaptation Index Calculation.

6.6 Preferred Project Portfolio – Planning for Uncertainty

Evaluating and prioritizing projects is a process that needs to consider uncertainty. Final project selection necessarily includes consideration of time frames for implementation, and the uncertainty involved in planning assumptions. Approaches for incorporating this uncertainty into final project selection are varied, and include:

- Adaptive management,
- Robust decision making, and
- Decision-scaling.

The IRWMP guidelines (DWR 2010a) strongly encourage IRWMPs to incorporate principles of adaptive management in the planning process. Principles from all three of these approaches are woven into this handbook, and are discussed in detail in Section 7.

This page intentionally left blank.